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Brilliant gamma-ray emission from near-critical plasma interaction with ultraintense laser pulses

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γ-ray is the electromagnetic radiation having the highest photon energy and smallest wavelength, which has a broad range of applications in industry, material science, nuclear physics, astrophysics and so on. In this talk, I shall report on recent progresses on studies of laser-driven brilliant gamma-ray radiation at Peking University (PKU). The PKU research team has carried out a series of theoretical and numerical studies [1-5] on brilliant γ-ray radiation production by using near-critical plasmas interaction with intense circularly polarized (CP) lasers. In this regime, a novel resonant acceleration scheme can be achieved [1, 2] for generating dense relativistic electron bunches and emitting brilliant γ-ray pulses, where the laser frequency matches with that of electron betatron oscillation under quasistatic electromagnetic fields in plasma. 3D PIC simulations show that brilliant γ-ray radiation with energy of 3J and brightness of 10^{24}photons/s/mm^2/mrad^2/0.1%BW (at 3MeV) can be produced by using CP lasers at intensity 10^{22}W/cm^2. It is found [3, 4] that the total number of radiated photons scales as $a^2/(S)^{1/2}$ and the conversion efficiency scales as a^3/S, where $S=(n_e/n_c)a$ and a is the laser normalized amplitude. Further studies show [4,5] that if the laser intensity is increased to 10^{23}W/cm^2, the quantum electrodynamic (QED) effects are in favor of trapping and achieving resonance acceleration of electrons, resulting in production of brilliant γ-ray pulses with unprecedented power of 6.7PW and brightness of 10^{25}photons/s/mm^2/mrad^2/0.1%BW (at 15MeV). To the best of our knowledge, this is the γ-ray source with the highest peak brightness in tens-MeV regime ever reported in the literature.

[1] B. Liu et al., X. T. He, PRL 110, 045002 (2013).
[2] B. Liu et al., X. T. He, PoP 22, 080704 (2015).
[3] H. X. Chang, B. Qiao et al., PRE 92, 053107 (2015).
[4] H. X. Chang, B. Qiao et al., Sci. Rep. accepted (2017).
[5] T. W. Huang, C. T. Zhou, B. Qiao et al., APL 110, 021102 (2017).